

a violent storm moved northeast between that place and Hallsville at 1.30 a. m., attended by heavy thunder and hail and followed by heavy rain; eight persons were killed, and the damage to property was estimated at \$1,500. The storm occurred at Longview, Tex., about 1 a. m.; a funnel-shaped cloud was observed; heavy hail fell and the thunder and lightning was continuous; damage, \$2,000. At Lufkin, Angelina Co., Tex., a severe storm moved northeast, with thunder, lightning, and rain; it passed through the county in a path about 1 mile wide and 25 miles long; several persons were seriously injured, and considerable damage was done to timber. A storm, with a funnel-shaped cloud and having a whirling motion, moved northeast over Holland, Tex., about 4 p. m.; damage, \$1,000.

19th.—A severe thunder and wind storm occurred at Helena, Ark., at 4.30 p. m.; a funnel-shaped cloud was observed; damage was done to the extent of \$25,000. A storm moved northeast near Lufkin, Tex., about 9 a. m.; it passed 12 miles through the county in a path 50 yards wide; a funnel-shaped cloud, with a whirling motion, was observed; very heavy rain, thunder, and lightning continued all day after the storm; damage to buildings, \$5,000. A storm moving north over Nacogdoches, Tex., about 7 a. m., caused damage to the extent of \$1,000. A severe storm, with a funnel-shaped cloud, moving northeast, passed over the vicinity of Leonard, Tex., at 8 p. m.; heavy rain and large hail fell, and the thunder and lightning was continuous; an infant was killed and a house destroyed. A storm struck Bartlett, Williamson Co., Tex., about 3 a. m.; 2 churches and number of buildings were destroyed. The heaviest rain-storm in years prevailed in the vicinity of Denison, Tex.; all streams overflowed and great damage was done to bridges and farms.

20th.—At New Orleans, La., during a high wind and thunder storm, damage was caused to the extent of \$5,000. A destructive storm passed over the north part of De Soto Parish, La., killing 1 person and destroying several houses. A violent windstorm occurred at Purvis, Miss., at 5 a. m.; damage was done to timber and outhouses and some stock killed. A heavy storm of wind and rain, attended by thunder and lightning, struck Natchez, Miss., shortly after midnight, causing minor damage. A storm of wind and rain visited the vicinity of Lumberton, Miss., during the early morning;

damage was done to fences and trees. High wind in the early morning caused minor damage at Little Rock, Ark.

21st.—During a heavy thunderstorm at Millville, N. J., 1 person was killed and another stunned by lightning. A severe thunderstorm occurred in the west part of Pittsylvania County, Va.; 1 person was stunned by lightning and a house damaged. A thunderstorm occurred at night at Houston, Mo.; a child was struck by lightning. Heavy snow and wind storms prevailed over North Dakota, South Dakota, Nebraska, and Minnesota; in some instances these began on the 19th and continued until the 22d. At Duluth, Minn., a sleet, rain, and wind storm prevailed on the 21st, changing to a heavy snow-storm on the 22d; damage was done to electric wires and trees by the accumulation of heavy ice, and street car traffic was delayed. At Valentine, Nebr., a storm of snow and high wind began at 11 a. m., and continued until the morning of the 22d. The snow drifted badly, delaying railroad traffic and causing loss of stock. At Bismarck, N. Dak., a storm of snow and wind began at 9.40 p. m., 19th, and prevailed until the 21st; all traffic was delayed. The most severe snow and wind storm since March, 1888, began at Rapid City, S. Dak., at 3.10 p. m., and continued during the 22d. All trains were blockaded, business suspended, and the loss of stock was heavy.

22d.—During a thunderstorm at Langley, Va., a barn was struck by lightning and 3 horses were killed. A report from Louisville, Ky., states that severe local storms occurred in Kentucky, along the Ohio River, in the morning. At Owensboro, Ky., a storm, possessing some of the characteristics of a tornado, occurred at 6 a. m.; valuable stock was killed and damage was done to property. A violent downpour of hail occurred at New Albany, Ind., at 6 a. m.; much damage was done. During a thunderstorm in the early morning at St. Louis, Mo., damage was done by lightning to the extent of \$33,000.

23d.—A severe thunder and wind storm passed over Bridgeton, N. J., in a path 100 to 200 feet wide, at 1.30 a. m.; houses and barns were destroyed. During a storm at Washington, N. C., 4 boats were capsized and 2 persons drowned. At Fargo and Fort Berthold, N. Dak., severe snow and wind storms caused loss of stock and damage to property.

24th.—At Crookston, Minn., a windstorm at night caused damage to roofs and electric wires.

ATMOSPHERIC ELECTRICITY.

GENERAL STATISTICS.

The table on page 120 shows in detail for March, 1894, the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month.

THUNDERSTORMS.

A mention of the more severe thunderstorms reported during the month is given under "Local storms." The dates on which reports of thunderstorms were most numerous were: 4th (188), 14th (106), 15th (243), 17th (133), 18th (166), 22d (190). The States from which the most numerous reports were received were: Louisiana, 143; Missouri, 121; North Carolina, 102; Ohio, 163.

AURORAS.

The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be those of the four days preceding and following the date of full moon, viz, from the 17th to 25th, inclusive. On the remaining twenty-two days of the month 782 reports were re-

ceived, or an average of thirty-six per day. The dates on which reports of auroras were especially numerous were: 2d (24), 8th (45), 30th (629), 31st (35); on the 23d, notwithstanding the moonlight, 16 reports were received, mostly from Minnesota, Michigan, Montana, New York, North Dakota, South Dakota, Wisconsin, and, after making a general allowance for moonlight, it seems proper to include the 23d among the dates of frequent auroras.

The aurora of the evening of the 30th was remarkable in several respects. It was visible at 629 stations in the United States, and the few reports that have been published from Canada and Europe show that we can not yet indicate, even approximately, the limits of the area over which it was observed. Its southern limit in the United States is indicated by its visibility at one, two, or three stations in Georgia, Alabama, Mississippi, Arkansas, Kansas, Colorado, Utah, Nevada, Oregon, and Washington. Notwithstanding the fact that many of our third order stations pay no special attention to the reporting of auroras, yet 50 per cent, or more, of the stations in Virginia, Tennessee, Kentucky, Illinois, Michigan, Indiana, Ohio, Pennsylvania, Maryland, Delaware, New

Thunderstorms and auroras, March, 1894.

States.	No. of stations.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	Total.		
Alabama	52	T.					1	1	2	1		4	1		1	5	7	2			5			1	1	1						1	33		
Arizona	53	T.		1													1	3															5		
Arkansas	46	T.			2	8		1			4	3		1	7	9	5	7	13	11	5	5	5				1				1	1	89		
Colorado	79	T.		1	1					1	1								4												6	1			
California	316	T.		1						1	1							1															2		
Connecticut	25	T.																		2				1								3			
Delaware	4	T.					1									1					2		2	2							15	10			
District of Columbia	4	T.																					1	1	1						4	7			
Florida	36	T.		2				1	1	2	1	1	7	1					1	1	1			1	4	11	4	1			1	41			
Georgia	52	T.						6	1	2		15	3		3	2	5	1		1	7			5	2	3			1		2	59			
Idaho	22	T.		1										1																1		7			
Illinois	59	T.			6	2		5		1	1	1			11	14	1	1	12	2		3	8								1	69			
Indiana	45	T.						7							1	16				7	3	5		14							25	28			
Indian Territory	7	T.			1	1									1			2													20	53			
Iowa	75	T.			26	1	1				2		1		25	3		1	16	2		1						2				81			
Kansas	81	T.		1	29				1		1				3	1		13	2	1											2	52			
Kentucky	40	T.						2						2		10	1	4	9		4	1	11								22	44			
Louisiana	53	T.			2	8	2	7	1	12		3	1			4	20	13	7	19	4	3	12	1	13	2			4	4		143			
Maine	19	T.																1														13			
Maryland	24	T.		2						3						1	1				2	1	7	10	7							15			
Massachusetts	84	T.		1	12	1																				1	1	1			45	67			
Michigan	79	T.			1	4	1				2		1		1	1		7	19	2	2	1	1								31	43			
Minnesota	78	T.			38	4	1				1				3			8	3		11	3	3	6							15	73			
Mississippi	43	T.				2		1	1	1	1	10			1	12	13	5	5	6	10	1	10	1							3	80			
Missouri	96	T.			22	17	1	1			1				9	21		6	19	2	5	6	8				1				6	121			
Montana	20	T.																													1	7			
Nebraska	69	T.			23	1															2	1	1								2	32			
Nevada	46	T.													1	1		6													5	8			
New Hampshire	29	T.																														2	4		
New Jersey	57	T.		3	5		2			4																						14	24		
New Mexico	29	T.													7	2			1	1		8	8	9							38	41			
New York	81	T.										1		2		1			3			7										3	4		
North Carolina	56	T.		1					7	11	2	7	8		4	11	6	21	3		2	10		12	1					3		102			
North Dakota	33	T.		1	1		3											1	1												2	22			
Ohio	135	T.		1				2	2		2					2	64		2	3	6	26	7	46	2						1	163			
Oklahoma	18	T.			1	8	1												4	4												18			
Oregon	70	T.																															0		
Pennsylvania	88	T.		1											4	2	15			1				17	4							8	45		
Rhode Island	9	T.																														40	42		
South Carolina	43	T.							3		7	2	10	1		11	6	4	10	3	1	3	3									7	64		
South Dakota	39	T.				6																2									15	15			
Tennessee	43	T.		1				2	1		3								2	9	7	6		6	6						1	19			
Texas	68	T.			3	1	5	3	1	3	2	1	2	2		1	4	3	3	8	5	6	2		3	1					20	77			
Utah	36	T.																															60		
Vermont	15	T.																														7	3		
Virginia	39	T.		1						2																						6	12		
Washington	46	T.																														19	32		
West Virginia	36	T.																														4	2		
Wisconsin	62	T.				12																										16	36		
Wyoming	14	T.		2																												22	58		
Sums	2,653	T.	A.	2	13	6	188	51	10	42	10	39	27	75	30	21	106	243	84	133	166	78	94	93	190	54	21	19	5	5	6	9	7	8	1835
				6	24	3	3	2	4	45	3	3	2	0	3	1	2	2	2	0	0	0	0	1	4	16	4	1	3	5	629	35	809		

Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine report the existence of a remarkably fine display of aurora, beginning in the early evening. This aurora, both in America and Europe, was intimately associated with two areas of high pressure that had pushed further south than usual; in the United States high area No. XVIII had moved south and east over the Gulf States and was, on the evening of the 30th, central off the south Atlantic coast; in Europe a great area of high pressure had pursued an almost parallel course southward over the North Sea and eastward toward the Black Sea, where it was central on the evening of the 30th; pressure was decidedly above the normal over the central North Atlantic Ocean between the 30th and 50th parallels as well as over western Europe and eastern North America; the only important depression was developing in the neighborhood of Newfoundland. The auroral light was first observed in Great Britain about 10 p. m. of the 30th, Greenwich time (which is simultaneous with 5 p. m. of the 75th meridian, or the standard time of the Atlantic States and of the Weather Bureau), but the electric disturbance, as shown by its effects on the magnetic needle at Washington, had already begun at 6 a. m. of the 30th, at which time also heavy frosts and freezing weather were prevailing from Washington southward to Georgia. Thus, the American display of the 30th took place principally over the region where cold air prevailed at the surface of the ground, while an upper current had apparently started to flow rapidly toward the northwest and north in its circulation around low area No. XXI, which was then central in Manitoba. Similar conditions prevailed in Europe, where the auroral light also appeared, principally on the northwest border of a region of high pressure, from which cold air was flowing into a low pressure over the Atlantic; these are the normal atmospheric conditions under which extensive auroras generally appear, but in this case they were transferred further south than usual. In the extreme north there is a large polar region where the auroral light is always observed to the south and rarely or never in the zenith or the north, thus showing that the atmospheric conditions favorable to auroras and which brought about the present display so far south in the United States must be comparable with those that generally prevail in this northern zone of greatest auroral frequency. The general displacement of the magnetic curves, which, as before said, begun at about 6 a. m. at Washington, was followed by rapid alternations at 3 p. m., which reached their maximum at about 8.40 p. m., and had ceased by 2 a. m. of the 31st. We have no knowledge at present as to the connection between the different phases of magnetic disturbance and the appearance of the auroral light, but it is a plausible hypothesis that the gradual displacement between 6 a. m. and 3 p. m. represents an increasing electric strain, while the rapid alternations between 3 p. m. and 2 a. m. represent the effect of rapid discharges and the resulting restoration of the previous state of equilibrium. From this point of view we should expect the auroral light to have first appeared in the central region, where the discharges occurred at 3 p. m., and this conclusion accords with the fact that in the region where the present aurora was most brilliant, viz, from Washington, D. C., to Boston, Mass., and especially at coast stations, such as Boston and Nantucket, Mass., and Cape May, N. J., the auroral light was noticed as soon as the twilight had progressed sufficiently to bring out its fainter light by contrast; in fact, at Block Island, R. I., the observer's record begins with sunset, and several stations report it as having begun within forty minutes after sunset.

As we proceed from this central region northeast, northwest, or southwest toward the interior the interval between sunset and the beginning of the aurora increases, but quite irregularly; it amounts on an average to one hour and twenty

minutes for Lake Erie and Lake Ontario, one hour and twenty-five minutes for South Carolina, and one hour and forty minutes for Maine; on the other hand the interval was apparently only forty-five minutes at La Crosse, Wis., and Dubuque and Davenport, Iowa, and fifty minutes in Tennessee and Kentucky, so that the irregular region of earliest appearance after sunset may be said to have extended from Block Island, R. I., and Marthas Vineyard, Mass., to Cape Hatteras, N. C., and thence westward over Maryland into Tennessee and Kentucky.

The beginning of the auroral light in England at 10 p. m., Greenwich, or 5 p. m. eastern or standard time, and therefore two or three hours earlier than as seen along our coast, should be considered, not in reference to absolute direction in space, but rather in reference to the time of sunset. In five hours after the Greenwich meridian assumes a certain position in space the diurnal rotation of the earth will bring the seventy-fifth meridian into that same position; this is true for all seasons of the year, and if auroras depend upon absolute position there should, therefore, be a difference of five hours in the absolute time of their occurrence on these two meridians. If, on the other hand, the aurora depends upon the condition of the moisture of the atmosphere, then the time elapsed since sunset and the general climatic conditions would be appreciable factors. In the present case the aurora appeared in Great Britain long after sunset, viz, from three to four hours, so that the central region of the disturbance and of the conditions most favorable for auroras was evidently far from that country.

If each observer could be sure that he was looking at the same spot of light as his neighbor to the north or south of him, he might determine, approximately, the height of the auroral light by the consideration that our most southern observers saw it to the north at an altitude of 10°, 20°, or 30°, while our most northern observers saw it to the south at an altitude of 50°, 60° or 70°; from such considerations as these the reports of observers 500 miles apart can be construed as demonstrating an altitude of from 100 to 300 miles; but such a computation rests upon the wholly indefensible hypothesis that distant individuals are observing the same spot, whereas the best observers, beginning with Bravais and Lottin in 1838, have repeatedly demonstrated that persons distant but 5 or 10 miles from each other do not see the same spot.

The auroral light of March 30 must be looked upon as a thin sheet at a low altitude which spread gradually over the surface of the country from our middle Atlantic coast north, west, and south as rapidly as the atmospheric moisture came into a condition proper to convert the electric discharge into the auroral light. From this point of view, we more clearly understand the phenomena called the "merry dancers," which consist of spots or waves of light moving rapidly from the horizon up toward the zenith and rarely occupying more than two seconds in this movement; even observers a few miles apart describe them as visible simultaneously all around the horizon; they usually begin at some small altitude, say 10° above the horizon, and disappear when they come within 10° of the zenith; when low down they are like little clouds or patches of light, but before they disappear near the zenith they have become smaller. It must be apparent that if several observers simultaneously see such phenomena as these, then we have here to do with an optical illusion which is easily explained by the laws of perspective; these patches of light are not moving from all directions horizontally toward each observer's zenith, but, on the contrary, they start from points near the horizon in the immediate neighborhood and move upward along lines that are all parallel to the free dipping needle; therefore, they all apparently converge by perspective toward the so-called magnetic zenith

precisely as do the stationary beams of light that generally precede the appearance of the "merry dancers." The points at which these fleeting clouds begin and end their upward movement represent the bottom and top of the layer within which the whole auroral display is going on, and probably the same may be said as to the lower and upper ends of the brilliant, definite, and long enduring beams of light generally called "streamers." These rapidly moving flashes of light, like ordinary lightning, appear to represent electric discharges between the earth or lower atmosphere and the upper atmosphere, and it is during their continuance that the magnetic needles are most violently disturbed, as though, at that time, the discharges were taking place nearest to the station, or as though they required most violent fluctuations in the local potential, or difference of potential, in order to produce them. In this connection the reader should study the diagram given on Chart VIII.

EARTH CURRENTS AND MAGNETIC STORMS.

Disturbances on the telegraph lines were reported at a few stations in this country on the 30th in Ohio, Wisconsin, and between Boston, Mass., and Buffalo, N. Y., at 5.30 p. m., increasing until at 7 p. m. the trouble had become general and

a wire from Boston, Mass., to Manchester, N. H., was run by the earth current alone; the line from Boston, Mass., to St. John, N. B., also showed much disturbance. The noises on government telephone lines in Great Britain were especially studied by the General Superintendent, Mr. Preece.

By the kindness of the Superintendent of the U. S. Naval Observatory it becomes possible to give on Chart VIII a facsimile of the curves of the self-registering magnetic declination, horizontal force, and vertical force during the 29th and 30th, from which it will be seen that the disturbances of the magnetic needle were unusually large and violent.

BALL LIGHTNING.

Dr. Howard Shriver, of Cumberland, Md., reports, with reference to an electric storm on March 21, that a lightning flash struck nearly two miles southwest of the town, and the same crash seems to have also reached close to the town where the lightning and thunder were not more than one and one-half seconds apart.

A Mrs. Brackett, while standing at her window, saw a "ball of fire" about as big as your two fists pass rapidly (apparently *along down outside of the window pane*), *ending in an explosion like a gun*. The explosion was heard by others in the house. The electric wires were so injured as to need repair in this part of the house only.

STATE WEATHER SERVICES.

[Temperature in degrees Fahrenheit; precipitation, including melted snow, in inches and hundredths.]

The following extracts and summaries are republished from reports for March, 1894, of the directors of the state weather services. The Maryland service includes Delaware and the District of Columbia. The New England service includes the six New England States. The organization of a service for Alaska, under the director of the California State service, is contemplated.

ALABAMA.

Temperature.—The mean was 4.5 above the normal; maximum, 88, at Tuscaloosa, 19th; minimum, 15, at Newburg, 27th; greatest monthly range, 70, at Newburg; least monthly range, 49, at Opelika.

Precipitation.—The average was 1.04 below the normal; greatest monthly, 11.51, at Mobile; least monthly, 1.31, at Sturdevant.

Wind.—Prevailing direction, south.—*F. P. Chaffee, Local Forecast Official, Weather Bureau, Montgomery, director.*

ARIZONA.

Temperature.—The mean was 2.0 below the normal; maximum, 96, at Palomas, 28th; minimum, —9, at Whipple Barracks, 5th; greatest monthly range, 88, at Whipple Barracks; least monthly range, 49, at Peoria.

Precipitation.—The average was normal; greatest monthly, 5.20, at Flagstaff; least monthly, 0.00, at Walnut Grove.

Wind.—Prevailing direction, southwest.—*W. R. Burrows, Observer, Weather Bureau, Tucson, director.*

ARKANSAS.

Temperature.—The mean was 3.5 above the normal; maximum, 88, at Ashdown, 13th; minimum, 8, at Rogers, 26th; greatest monthly range, 75, at Rogers; least monthly range, 55, at Mount Nebo.

Precipitation.—The average was 4.86 above the normal; greatest monthly, 18.20, at Madding; least monthly, 4.38, at Texarkana.

Wind.—Prevailing direction, south.—*F. H. Clarke, Local Forecast Official, Weather Bureau, Little Rock, director; G. G. Harkness, Observer, Weather Bureau, assistant.*

CALIFORNIA.

Temperature.—The mean was 1.6 below the normal; maximum, 105, at Volcano Springs, 28th; minimum, —7, at Truckee, 3d; greatest monthly range, 67, at Winchester; least monthly range, 26, at Point Lobos.

Precipitation.—The average was 2.00 below the normal; greatest monthly, 15.41, at Crescent City Lighthouse; least monthly, 0.00, at a number of stations.

Wind.—Prevailing direction, west.—*J. A. Barwick, Observer, Weather Bureau, Sacramento, director.*

COLORADO.

Temperature.—The mean was 2.0 above the normal; maximum, 85, at Minneapolis, 16th; minimum, —19, at Gunnison, 7th; greatest monthly range, 76, at Brush; least monthly range, 43, at Pikes Peak.

Precipitation.—The average was 0.50 below the normal; greatest monthly, 4.81, at Climax; least monthly, trace, at Las Animas, Monte Vista, and Sanborn.

Wind.—Prevailing direction, west.—*G. A. Loveland, Observer, Weather Bureau, Denver, director.*

CONNECTICUT.

Temperature.—The mean was 6.6 above the normal; maximum, 72, at Canton, 19th; minimum, 11, at Voluntown, 27th; greatest monthly range, 60, at Canton; least monthly range, 44, at New London.

Precipitation.—The average was 2.94 below the normal; greatest monthly, 2.07, at New London; least monthly, 0.94, at North Grosvenor Dale.

Wind.—Prevailing direction, southwest.—*J. Warren Smith, Weather Bureau, Boston, Mass., director.*

DELAWARE.

Temperature.—Maximum, 84, at Milford, 22d; minimum, 17, at Millsboro, 28th; greatest monthly range, 65, at Millsboro and Milford; least monthly range, 58, at Dover.

Precipitation.—Greatest monthly, 1.60, at Millsboro; least monthly, 1.18, at Seaford.

Wind.—Prevailing direction, southwest.—*Dr. William B. Clark, Johns Hopkins University, Baltimore, Md., director; C. P. Cronk, Observer, Weather Bureau, in charge.*

FLORIDA.

Temperature.—The mean was 1.5 above the normal; maximum, 93, at Archer, 22d, and at Kissimmee, 21st; minimum, 29, at Pensacola and Tallahassee, 27th; greatest monthly range, 59, at Archer; least monthly range, 22, at Key West.

Precipitation.—The average was 1.25 below the normal; greatest monthly, 7.52, at Pensacola; least monthly, 0.53, at Orange City.

Wind.—Prevailing direction, east.—*E. R. Demain, Observer, Weather Bureau, Jacksonville, director.*

GEORGIA.

Temperature.—The mean was 4.0 above the normal; maximum, 92, at Brag and Fleming, 22d; minimum, 15, at Dahlonga, 27th; greatest monthly range, 69, at Elberton; least monthly range, 53, at Hephzibah.

Precipitation.—Greatest monthly, 7.12, at Thomasville; least monthly, 1.71, at Leverett.

Wind.—Prevailing direction, south.—*Park Morrill, Local Forecast Official, Weather Bureau, Atlanta, director.*

IDAHO.

Temperature.—Maximum, 72, at Boise Barracks, 27th; minimum, —12, at Lake, 5th; greatest monthly range, 66, at Fort Lemhi; least monthly range, 31, at Atlanta.

Precipitation.—Greatest monthly, 7.35, at Garden Valley; least monthly, 0.40, at Kootenai.

Wind.—Prevailing direction, south.—*J. H. Smith, Observer, Weather Bureau, Idaho Falls, director.*